ON THE MINERAL WATER

DISCOVERED IN SINKING THE

ARTESIAN WELL AT ST. CLEMENT'S, OXFORD

AND ON CERTAIN

GEOLOGICAL INFERENCES SUGGESTED BY THE CHARACTER OF THE WATER

BY

JOSEPH PRESTWICH, M.A., F.R.S.

Professor of Geology in the University of Oxford

Read before the Ashmolean Society, Monday, June 12, 1876.

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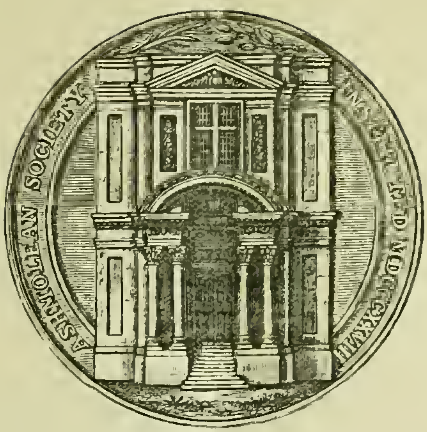

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THE MINERAL WATER

DISCOVERED IN SINKING THE ARTESIAN WELL AT ST. CLEMENT'S, OXFORD, WITH THE ANALYSIS THEREOF BY W. F. DONKIN, M.A.

In the course of my enquiries last summer respecting the possibility of procuring from springs or by means of artesian wells a water of better quality than that at present supplied to Oxford by the Thames[1], I met with one water so strongly impregnated with salts as to constitute a true mineral water of a quality to deserve more special notice.

Amongst the trial borings, made for the purpose of obtaining either coal or water, and noticed as illustrations of geological structure by Professors Hull[2] and Phillips[3], is an artesian well at the St. Clement's Brewery, Oxford, made in 1832 and carried through Oxford clay and Oolitic strata to the depth of 420 feet. From the silence of both these gentlemen on the subject of water, I presumed that none had been met with, but on visiting the spot I found a small supply of water trickling from the bore-hole on the surface, which is there about 10 ft. above the level of the river Cherwell. I was informed that when the bore-hole was first made, the water rose 3 or 4 ft. above the surface in a considerable volume, but it was found to

[1] 'On the Geological Conditions affecting the Water Supply, etc., to Oxford.' Parker, 1876.

[2] 'Memoirs of the Geological Survey.' Sheet 13, given on the authority of the Rev. A. D. Stackpoole.

[3] 'Geology of Oxford,' p. 297.

be so saline as to be totally unfit for either trade or domestic purposes, and it has since consequently been allowed to run to waste [1].

I was not aware at the time of the publication of my paper 'on the water supply,' that this well water had been previously noticed. I have now however discovered that so long ago as 1835 it had attracted the attention of Dr. Buckland, by whom it had been brought to the notice of the Geological Society of London [2].

Since then the well seems to have dropped into oblivion, and I can find no further mention of it. As the subject is one of considerable interest both with respect to the character of the water, and in its geological bearings, I beg to submit a few more details and certain theoretical conclusions respecting it to this Society, and to give a short account of the other mineral waters of England and the continent which the Oxford spring most closely resembles.

A sample of the water was submitted to my friend Mr. W. F. Donkin, who kindly furnished me with the analysis given at p. 15. This shows that in 100,000 parts of the water, there are 1824 parts of solid matter, which is equal to 1277 grains per gallon,—or rather more than half the

[1] I understand also that the tube is partly blocked up.

[2] In vol. ii. of the 'Proceedings of the Geological Society of London for June 1835,' p. 204, appears the following short statement:—

'An extract was lastly read of a letter from Dr. Daubeny. In this letter Dr. Daubeny gives the analysis of the mineral spring lately discovered near Oxford, and announced to the Society by Dr. Buckland at the meeting held on the 29th of April.

'Dr. Daubeny says the water at the time the analysis was made (March 26th) contained more sulphuric salts than any other spring in this country. The following were the saline contents of a pint of water:—

'Chloride of sodium	70·82
,, calcium	7·25
,, magnesium	2·40
Sulphate of soda	52·40
	132·87'

On referring to the previous meeting of the 29th of April I cannot find any notice of the communication referred to, nor does Dr. Buckland mention the subject in any of his published papers. There can however, I think, be no doubt that the notice of Dr. Daubeny refers to the artesian well at St. Clements, although not so specified.

quantity contained in sea water—and is more than is contained in any of the English saline waters, nor is it exceeded by many of the continental waters of the same class.

The most noticeable fact in Mr. Donkin's analysis is the large proportion of *sulphates*, a point which had not failed to attract the attention of Dr. Daubeny[1]. The proportion is larger than in any other mineral waters in this country, and approaches more nearly to that of some of the German mineral waters, such as those of Friederichshall and Rehme. For the purpose of comparison I have given at the end of this paper, a table of some of the more closely allied waters of England and the continent reduced to a common measure—the imperial gallon.

Amongst the English mineral waters, the St. Clement's water most resembles those of Cheltenham and Leamington. But, whereas at Cheltenham the quantity of the *sulphate of soda* averages 104 grains per gallon, at St. Clement's it amounts to 357 grains, while the proportion of *chlorides* in the two waters is as 545 : 775 grs.; the total relative quantities of saline ingredients in each being, Cheltenham 694 grains, St. Clement's 1277 grains. The *sulphate of lime*, which forms also a considerable item in the latter, is absent in the former, which on the other hand contains more *iodides* and *bromides*.

At Leamington although the *chlorides* and the *sulphates* are in excess of those at Cheltenham, they both are still less in quantity than at St. Clement's. Thus the *chlorides* are as 670 : 775. and the *sulphates* as 258 : 492, or nearly one half less than at St. Clement's. Another point of difference is the excess of lime salts at Leamington.

Though therefore the water of St. Clement's is to be classed in general character with those of Cheltenham and

[1] Dr. Daubeny does not say whether he used the old pint or the imperial pint. If an imperial pint the proportion per gallon of saline matter he found would be 1063 grains. If the old pint it would be about 1200 grains per gallon, which is very near the present quantity of 1277 grains determined by Mr. Donkin. The only additional substances noted by the latter are a small quantity of carbonate of lime amounting to 7½ grains per gallon, of silica rather more than a grain, and of ammonia the tenth of a grain, but the essential point which attracted the notice of Dr. Daubeny, namely, the large proportion of sulphates, remains unaltered.

of Leamington, the contained salts vary considerably both in their relative proportions and in total quantity. It is to be observed also that the several springs at Cheltenham and Leamington differ between themselves very considerably in the quantity of saline ingredients they contain. The Cheltenham waters vary from 345 to 1033 grains per gallon, and those of Leamington from 740 to 1084 grains, so that on the average as the St. Clement's water contains 1277 grains, it is, besides having so much larger a quantity of *sulphates*, nearly twice as strong, on an average, as those of Cheltenham, and about a fourth stronger than those of Leamington.

With the other south of England mineral waters, the St. Clement's water presents no analogies. That of Purton, near Swindon, contains about 400 grains of solid matter in the gallon, and is distinguished by the presence of very small proportions of the *bromide of potassium* and *iodide of magnesium*, and by a larger proportion of the *carbonate* and *sulphate of lime*. The Bath waters on the other hand are distinguished chiefly by their high temperature; the total saline ingredients, which consist in greater part of *sulphate of lime*, with small quantities of salts of *potash* and *iron*, amounting only to 144 grains per gallon.

The spring at Christian Malford, near Chippenham, contains 580 grains of solid matter per gallon. Of this 484 grains consist of the *chlorides of sodium* and *potassium*, with only 96 grains of salts of *lime* and *magnesia*, and a small quantity of *bromide of magnesium*.

Small chalybeate springs are very common in many of our sand and sandstone strata, and others, containing an excess of *sulphate of magnesia* (Epsom salts), are not uncommon in connection with our clay formations—the London clay especially.

Nor does the St. Clement's water resemble any of the north of England mineral waters. The Buxton waters are hot, and differ from that of St. Clement's in the absence of *sulphates*, and the presence of a large proportion of the *carbonates of lime* and *magnesia*, while Harrogate belongs to the class of *sulphuretted* waters.

If we now turn to the mineral springs of the continent, we find that the principal waters in which the *sulphates* are

in excess are those of Pullna, Saidschutz, and Seidlitz in Bohemia, of Rehme in Westphalia, and of Friederichshall in Saxe Meiningen. It is with the two latter that in most respects the St. Clement's water presents the nearest approximation. (See table, p. 16.)

At Friederichshall the total quantity of the *chlorides of sodium* and *magnesium* amounts to 836 grains, against 775 grains at St. Clement's; while of the *sulphates of soda, lime,* and *magnesia,* there are 805 grains against the 493 grains at St. Clement's. The relative proportions of the *sulphate of soda* are not so very different; but that which really constitutes the difference is the excess at Friederichshall of the salts of *magnesia;* for while we there have 577 grains of those salts, they are, with the exception of 27 grains of the *chloride of magnesium,* absent in the St. Clement's water[1].

The total quantity of salts in the Friederichshall water amounts also to 1749 grains, against 1277 grains in the St. Clement's water, the excess consisting chiefly of the magnesian salts.

The saline springs of Rehme in Westphalia differ greatly according to their depth. The deep hot springs contain a large proportion of *chloride of sodium* and small quantities of *sulphates.* In the shallower cold springs on the contrary the proportions are reversed, while the total is less by one half. In the latter the total solids (1400 grains) do not much exceed those at St. Clements. There is however a much larger proportion of *carbonate of lime* at Rehme, together with, as at Friederichshall, an excess, although not to the same extent, of the salts of *magnesia.*

The St. Clement's water presents also a certain analogy with one of the springs at Kissingen in Bavaria, which contains 1200 grains of *chlorides,* with however only 227 grains of *sulphates;* in its general proportions this water more resembles the Cheltenham waters, but it is stronger, the total quantity of solids amounting to 1489 grains.

Another weak saline water met with, some years since,

[1] It is these salts of magnesia which give those characters to waters known as bitter waters, of which Friederichshall constitutes so well known a type.

at Mézières in the north of France, presents in the relative proportion of its salts a curiously close resemblance to the St. Clement's water. The actual quantity of solid matter it contains is however only about half the quantity existing at St. Clement's, or 693 grains against 1277 grains. Of this total there are 327 grains of *chloride of sodium*, 204 grains of the *sulphate of soda*, and 55 grains of the *sulphate of lime*. This is almost in the exact relative proportion (about half of each) in which they occur at St. Clement's; the *carbonate of lime*, and the *chloride of magnesium* alone are in excess—but the quantity of these latter is very small. It will be shown presently that the presumed geological position of the two springs is probably alike.

Before proceeding to discuss the origin of the St. Clement's spring, which presents some points of considerable interest, I will say a few words on the position of mineral springs generally, and on the geological position of this particular class of springs.

The larger proportion of the mineral waters of Europe, including almost all the hot waters, are due to perennial springs rising naturally to the surface; but there is yet a certain number, increased largely of late years, which are of artificial formation. With the first we are not at present concerned. We may merely observe that they consist of hot springs which mostly occur either in volcanic districts or amongst mountain ranges, and that they are in general characterised by a more copious evolution of gases, and by the presence of bicarbonates of the alkalies, due to the decomposition of the silicates and carbonates in the deep-seated igneous and metamorphic rocks, by water holding carbonic acid in solution, under heat and pressure; and of cold springs, usually calcareous, saline, or chalybeate, generally at a distance from such centres, and varying according to the characters of the sedimentary strata in which they are placed.

The second section of mineral springs are true artesian wells. They have been discovered sometimes in sinking for salt or for coal, and, at other times, for water. They are almost all saline, because sunk in the one case directly in the New Red Sandstone

or Trias (the great storehouse of salt beds), or else the same formation has been traversed indirectly in seeking for the Coal Measures which it overlies, or reached in trying for water through the Lias which it underlies. The temperature of the water will necessarily depend on the depth at which it is met with, and assuming the underground temperature to increase at the rate of about 1° Fahr. for every 50 to 60 feet of depth, it is easy to estimate the heat any such spring would have by the depth of the water-bearing stratum.

The springs at Cheltenham and Leamington are almost if not all obtained artificially by wells sunk or borings made to depths of from 30 to 120 feet. Of course at such depths the water has only a temperature of 1° to 2° above the mean annual temperature of the place. Here at Oxford, the mean surface temperature being 49.3° Fahr., the temperature of the St. Clement's spring, if flowing freely, would be constant at 56° to 57° Fahr. One of the most remarkable instances of an artificial mineral hot spring is probably that of Rehme in Westphalia. A boring was there made in 1830 for rock salt to a depth of 2300 ft. No bed of rock salt was found, but at that depth a saline spring was met with which flowed above the surface, and of which the temperature is 92° Fahr.

Not however that hot springs must necessarily be mineral springs, because although water when hot acts more readily on rocks than cold water, there must be such minerals present as can be acted upon. When that is not the case, water may pass to a great depth, and yet issue quite pure, as in the case of the great artesian wells of Grenelle and Passy at Paris, which tap at a depth of 1800 ft. water that has travelled more than 100 miles underground, and acquired a temperature of 84°, and which nevertheless contains under 10 grains of solid matter per gallon, or less than one half as much as the Thames water at Oxford.

It is well known that, all over Europe, certain portions of the New Red Sandstone or Trias[1] contain beds of Rock Salt

[1] The lower division of the New Red Sandstone or the Bunter beds are generally free from salt, and yield water of very good quality, as in the case of large districts of the New Red in the centre and north of England. The great deposit of salt occurs in the upper division of the New Red Sandstone or the Keuper beds. Salt is also found in some of the Permian strata.

alternating with beds of Gypsum or sulphate of lime. In some cases the salt is worked like coal in pits. In other cases, as at Droitwich, it is obtained by wells, the water from which yields by evaporation a large quantity of salt. These are called brine springs, and some of them are so highly saturated as to contain, according to Mr. Horner, 265.3 solid parts in 1000 parts of water, whereas sea water contains only 35 parts. But instead of the solid ingredients consisting of *chloride of sodium* or common salt, in the ratio of 5 parts to 1 part of *sulphates* as in sea water, they exist in these brines in the greater disproportion of 28 to 1. Besides the more localised salt beds, the New Red Sandstone contains many beds more or less impregnated with salt, intermixed with seams and masses of gypsum, and it is from the water which percolates through such strata that the ordinary weaker saline springs are produced. In these springs the proportion of *sulphates* is always larger and this constitutes the important difference between them and ordinary brines.

The presence of *sulphate of lime* in these springs is due to its original deposition with the *chloride of sodium* in the strata formed in the lakes and lagoons of Triassic age, but the *sulphate of soda* must be due to subsequent chemical decomposition.

The Leamington wells are in beds of the upper New Red Sandstone, whence the *chlorides* and *sulphates.* Cheltenham stands on beds of the Lower Lias, but as the upper beds of the New Red Sandstone crop out a few miles west of Cheltenham, and pass under the Lias, geologists have concluded that the wells traverse the Lias and reach the New Red, and that it is from those beds that the saline water comes.

The geological position of the saline springs on the Continent is analogous to that of the English springs.

The Soolensprudel spring at Kissingen is situated on Triassic strata, into which a number of artesian wells have of late years been sunk, for the purpose of obtaining an additional supply to that afforded by the original spring.

I have already alluded to the remarkable springs of Rehme. They are sunk through the lower part of the Lias into the

upper beds of the New Red Series. They vary very much in strength, the hotter deeper springs containing as much as 41 parts of solid matter in 1000 parts of water, and the weaker ones only 19 parts, the former being stronger in *chlorides*, and the latter in *sulphates* as in the Friederichshall water.

The springs which yield this latter well-known water are situated ten miles from Coburg in Saxe Meiningen. They also rise in strata of Triassic age. Friederichshall has been long noted for its salt-works, and for the manufacture of Glauber salts (sulphate of soda), but its merits as a medicinal water have only been more recently recognised, especially since the sinking of artesian wells. The water is usually concentrated before exportation to the specific gravity of 1.022.

Mézières stands on the Lias. It was in boring for water that this formation was traversed, and the New Red Sandstone reached at a depth of 460 feet, when a saline spring was tapped and rose to the surface. The geological conditions are precisely similar to those of Cheltenham (and Rehme), but the thickness of the overlying strata is greater.

The peculiar waters of Seidlitz, with their large quantity of *sulphate of magnesia* and absence of *chloride of sodium*, rise in a Basaltic district. The Bath waters, which also contain chiefly *sulphates*, but in small quantities, rise possibly from Palæozoic strata.

On the other hand, mineral springs are extremely rare in the Oolites. These strata on the contrary usually abound in fine springs (of which there are many between Oxford and Cheltenham) of excellent potable water. Some *bicarbonate of lime* is always present in these waters, but they contain no more *chloride of sodium* than the few grains usually present in chalk or river water of good quality. The wells also sunk in the Oolites, both to the west and north of Oxford, are perfectly free from any excess of this salt. Nor could any of the beds connected with the Lias which there underlies the Oolites furnish the amount found at St. Clement's. The spring at Purton, in the upper Oolitic strata, contains 276 grains of *sulphates*, but only 34 grains of *chloride of sodium*.

Looking at all these facts, I conclude that the water at St. Clement's has its origin in the New Red Sandstone, and not in the Oolitic or Liassic strata, as would otherwise, from the depth of the boring, be the natural inference. If the water were from the Oolitic strata, we should expect to find it much purer, and its solid matter to consist chiefly of carbonate of lime: if from the Marlstone or Lias, to be more ferruginous and calcareous.

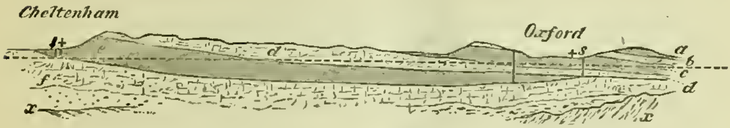
But this view involves some geological difficulties, and is not in accordance with the dimensions hitherto assigned to these formations under Oxford. I have however already shown that the Oxford clay is here not more than 350 ft. thick, instead of 600 ft., and from what is known of the upper two divisious of the Lias, which formation is about 900 ft. thick in the neighbourhood of Cheltenham, it is quite within the range of probability that it thins out altogether under Oxford.

The Oolitic strata, which have a thickuess of 520 ft. in Gloucestershire, are reduced to 130 ft. around Oxford, while the upper and middle Lias are reduced from 400 ft. to 25 ft., and there is reason now to suppose that in a similar way the lower Lias also thins out. My reading of the well-section at Wytham would show that the Lias was there sunk into, but not traversed, for a thickness of 150 ft., when a depth of 633 ft. was reached and the work abandoned. So to account for the presence of the New Red Sandstone at St. Clement's at a depth of 420 ft., we must suppose that both the lower as well as the upper divisions of the Lias have further thinned out altogether between Wytham and Oxford, or else that the New Red Sandstone is brought up by a fault. As no great fault has, however, been detected on the surface[1], and the dip required for the thinning out of the beds in the three miles distance would be but small, I am inclined to adopt the former view —viz. that, while the Oolitic strata, become much redueed, the whole of the Liassic strata, as they range underground from Cheltenham to Oxford, thin out, so that the Oolitic strata here immediately overlie the New Red Sandstone, as shown in the following diagram.

[1] Still an old fault of pre-oolitic age may exist below ground and not show on the surface.

If this should be the case, and the New Red Sandstone be found at the depth of about 420 ft. beneath Oxford, an important economical problem is raised.

DIAGRAM-SECTION FROM THE VALLEY OF THE SEVERN TO SHOTOVER HILL, NEAR OXFORD.



a Kimmeridge Clay, etc.
b Coralline Oolite.
c Oxford Clay.
d Great and Inferior Oolites.
e Lias.
f New Red Sandstone.
x Possible position of the Palæozoic strata.
s St. Clement's well.

In my Reports[1] to the Coal Commission of 1869, of which I had the honour to be a member, I expressed an opinion that the Coal Measures and the other Palæozoic strata which pass beneath the Lias and Oolites between Bath and Frome, are prolonged under these strata in an east-north-east direction through Wiltshire and Oxfordshire, and thence to the south-east of England. The facts here investigated, so far as they go, are in accordance with this view; and as the same cause which affects the dimensions of the Jurassic strata, viz. the shallowing of the old Jurassic and Triassic seas near the old Palæozoic land, would in all probability affect the New Red Sandstone, the thickness of the secondary strata here would probably offer no serious impediment to reaching the older underlying Palæozoic rocks.

The New Red Sandstone is of great thickness in the Midland Counties, but becomes very much reduced in the neighbourhood of Bath, where the Coal Measures are in places worked under it, and it is not improbable that in like manner it is of moderate thickness in Oxfordshire, thinning out against the old axis of Palæozoic rocks, which passes underground in continuation of and on the same east and west strike as the Mendips.

On the northern flanks of this ridge, and forming part of

[1] 'On the Probability of finding Coal under the New Red Sandstone and other superincumbent strata,' and 'On the Coalfields of Somersetshire and part of Gloucestershire.' Parliamentary Papers.

its Palæozoic strata, there may be underground a series of coal basins, just as there are aboveground along the same Palæozoic range, where it comes to the surface, in the West of England and in Belgium. Further, as the Triassic and Jurassic strata become thinner or altogether thin out on the northern side of the Mendips, if the same conditions obtain, as they appear to do, in Oxfordshire, the Palæozoic formations should, where the ridge was highest, immediately underlie the Oolitic and Cretaceous series, and the Coal Measures may thus be brought within workable depths from the surface.

This of course is to a certain degree speculative, but the fact that the water at St. Clement's has the character of water derived, not from the Oolites, but from the New Red Sandstone is evident; while it is also clear that the Oolitic strata and the upper two divisions of the Lias do become thinner as they range south-eastward to Oxfordshire.

Thus besides the interest attaching to the peculiar mineral character of the water, this character involves a point of much geological significance from its corroborative bearing on the hypothesis of the probable existence of Coal Measures beneath the secondary strata somewhere in this part of England. But this is a question incidental to the original object of this paper, which was to lay before the Society the facts connected with the spring supplying the artesian well at St. Clement's, and to show how far it resembled other mineral springs of England and the Continent. Although we have spoken of it as a spring, it is really a level of water, co-extensive with the water-bearing stratum in which it lies, which is better expressed by the French term '*nappe*.' It in all probability underlies all Oxford, and could be reached anywhere within this area at a depth of 400 ft. to 500 ft., and would rise above or to within a few feet of the surface according to the level of the ground.

Into the medicinal properties of this water I do not presume to enter. The analysis of Mr. Donkin and the particulars of other saline springs I have given in the annexed

[1] 'On Mineral and Thermal Springs,' 1832.

table will serve to show its actual and relative character, but for the questions connected with the use of such waters, I must refer to the works, amongst others, of Dr. Gairdner[1], Dr. Althaus[1], Dr. Sutro[2], Dr. Macpherson[3], and MM. Herpin[4], Durand-Fardel[5], and Constantin James[6].

ANALYSIS OF THE WATER FROM THE ARTESIAN WELL AT ST. CLEMENT'S, OXFORD, BY W. F. DONKIN, M.A., 1876.

Sodium	583·50 in 100,000 parts.
Calcium	57·63
Magnesium	9·84
Chlorine	677·84
Sulphuric acid (SO_4)	475·47
Carbonic acid (CO_3)	6·55
Silica	1·80
	1812·63

The above may be grouped thus:—

Sodium chloride	1069·0
Sodium sulphate	510·9
Calcium sulphate (2 CaSO, H_2O)	193·1
Calcium carbonate	10·9
Magnesium chloride	38·9
Silica	1·8
Ammonia	0·1
	1824·7 in 100,000 parts.

With traces of potash, iron, and alumina

Weight of total solids dried at 170° C.	1831·5
Specific gravity of the water at 9° C.	1·01462

1 'The Spas of Europe,' 1862.
2 'Lectures on the German Mineral Waters,' 1865.
3 'Our Baths and Wells,' 1871, and 'The Baths and Wells of Europe.'
4 'Études médicales à Statistique sur les Eaux minérales,' 1856.
5 'Traité thérapeutique des Eaux minérales de France et de l'Étranger,' 1857.
6 'Guide aux Eaux minérales,' 1858.

MINERAL SPRINGS.

Saline Ingredients rendered in Grains per Gallon.	ENGLAND.						GERMANY AND FRANCE.				
	Oxford [1], St. Clement's.	Cheltenham [2],		Leamington [3], Bath Street Well.	Swindon [4], Purton Spring.	Bath [5], King's Bath.	Friederichshall [6], Saxe Meiningen.	Kissingen [7], Bavaria (the Soolensprudel).	Rehme [8], Westphalia (the Soole spring).	Mézières [9], France.	Seidlitz [10], Bohemia.
		Royal Old Well.	Pitville.								
	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.
Chloride of Sodium	748·30	590·33	481·19*	476·96	34·30	12·64	546·00	977·9	245·00	326·90	..
" Magnesium	27·23	8·00	..	115·44	..	14·58	289·80	222·6	140·00	75·18	..
" Calcium	.	..	..	78·00	..	..	..	..	70·00	..	..
Sulphate of Soda	357·63	94·94	115·82*	68·72	114·15*	23·87*	511·00	227·5	525·00	203·98	51·10
Magnesia	..	..	..	..	77·20	.	287·70	..	175·00	..	2227·40
" Lime	135·37	..	..	190·00	83·87	80·05	7·00	..	..	55·16	40·70
Carbonate of Soda..........	..	..	20·15	..	28 88*	..	50·40	..	..	..	..
" Magnesia......	..	6·80	11·39	..	..	0·33	..	58·8	35·00	..	10·00
" Lime	7·63	17·06	7·70	..	..	8·82	18·20	..	210·00	31·92	15·40
Bromide or Iodide of Sodium	traces	3·50	3·29	traces	0·16	..	1·40	traces	..	..	..
Iron....................	traces	..	..	traces	0·28	1·07	traces	2·8	..	..	..
Silica	1·26	2·75	2·77	traces	1·28	2·98	35·50 [11]	traces	..	..	..
Organic and Extractive Matter	0·10	18·39	3·85	..	8·75	..	2·80	..	..	..	5·90
Total	1277·52	741·77	646·16	929·12	348·87	144·34	1749·50	1489·6	1400·00	693·14	2350·50

[1] Donkin. [2] Abel and Rowney, 1848. [3] Given without name, 1873. [4] Voelcker, 1861. [5] Meek and Galloway, 1846. [6] O. Henry (Pelouze and Fremy), 1854. [7] Liebig (Constantin James). [8] Bischoff? (Sutro). [9] Wahart-Duhesme (Annuaire des Eaux, 1854). [10] Bouillon-Lagrange (Althaus). [11] With alumina and some alkaline carbonates.

NOTE.—The small quantity of potash salts met with in a few of these springs are included with the salts of soda marked with an asterisk.